

means for introducing a signal of wavelength  $\lambda_s$  into said gain fiber input end,

means introducing pump light of wavelength  $\lambda_p$  into said gain fiber, and

means for preventing the excitation of said pumped gain ions by light of wavelength  $\lambda_p$ .

22. A fiber amplifier in accordance with claim 21 wherein said unpumped gain ions are situated in a signal filtering optical fiber that is connected in series with said gain fiber.

23. A fiber amplifier in accordance with claim 22 wherein said means for preventing excitation is connected in series between said gain fiber and said filtering optical fiber.

24. A fiber amplifier in accordance with claim 23 wherein said means for preventing excitation comprises a fiber-type grating reflector for reflecting pump light.

25. A fiber amplifier in accordance with claim 23 wherein said means for preventing excitation comprises interference filter means for removing pump light.

26. A fiber amplifier in accordance with claim 23

wherein said means for preventing excitation comprises an optical fiber containing a dopant that substantially attenuates light at wavelength  $\lambda_p$ .

27. A fiber amplifier in accordance with claim 26 wherein said pump light attenuating optical fiber connects said signal attenuating fiber to the input end of said gain fiber.

28. A fiber amplifier in accordance with claim 26 wherein said gain fiber comprises first and second sections, and said pump light attenuating fiber comprises first and second sections, said fiber amplifier comprises the serially connected arrangement of the first section of said gain fiber, said first section of said pump light attenuating fiber, said gain ion-doped pump light attenuating fiber, the second section of said pump light attenuating fiber and the second section of said gain fiber, said means for introducing pump light comprising means for introducing pump light into said first and second gain fiber sections.

29. A fiber amplifier in accordance with claim 23 wherein means for preventing excitation comprises an optical fiber coupler which couples essentially no pump light from said gain fiber to said signal attenuating fiber.

30. A fiber amplifier in accordance with claim 21 wherein said means preventing excitation of unpumped gain ions by pump light comprises a sufficient length of gain fiber to dissipate all of the pump light introduced therein.

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31. A fiber amplifier in accordance with claim 21 wherein said absorbing ion filtering means comprises an optical fiber containing unpumped gain ions and a dopant for absorbing pump light, the concentration of said dopant being much greater than unpumped gain ions.

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32. A fiber amplifier in accordance with claim 21 wherein the radial distribution of said gain ions in said gain fiber extends beyond the mode field radius of light of wavelength  $\lambda_p$ , whereby those gain ions at radii greater than said mode field radius are unexcited by pump light and are free to absorb signal light.

33. A fiber amplifier in accordance with claim 21 wherein a section of said gain fiber is fused in side-by-side arrangement to a further section of optical fiber doped with gain ions to form a fused region into which signal light but not pump light can extend from said gain fiber into said further section, whereby those gain ions of said further section are unexcited by pump light and are free to absorb signal light.

34. A fiber amplifier in accordance with claim 21 said gain fiber is in series with an optical fiber containing signal light absorbing ions that are different from said gain ions.

35. A fiber amplifier comprising  
a gain optical fiber having only one single-mode core,  
said core containing gain ions capable of producing stimulated emission of signal light within a predetermined band of wavelengths including a wavelength  $\lambda_s$  when pumped with pump light of wavelength  $\lambda_p$ , said gain fiber having first and second ends,  
a filtering fiber containing gain ions for filtering signal light,

a pump light-attenuating fiber having a core containing a dopant that attenuates said pump light while signal light remains substantially unattenuated, said pump light-attenuating fiber connecting the second end of said gain fiber to an end of said filtering fiber,

means for introducing pump light of wavelength  $\lambda_p$  into the first end of said said gain fiber,

and means for introducing a signal of wavelength  $\lambda_s$  into one of the ends of the series combination of said gain fiber, said pump light-attenuating fiber and said filtering fiber, the gain ions of said filtering fiber remaining unexcited during operation because of the pump light filtering action of said pump light-attenuating fiber, whereby said filtering fiber

alters the spectral gain of said amplifier.

36. A fiber amplifier comprising

first and second gain optical fiber sections, each having only one single-mode core, said core containing dopant ions capable of producing stimulated emission of light within a predetermined band of wavelengths including a wavelength  $\lambda_s$  when pumped with light of wavelength  $\lambda_p$ , each gain fiber section having first and second ends,

first and second pump light-attenuating fiber sections, each having a core containing a dopant that attenuates optical power in at least one wavelength band including said wavelength  $\lambda_p$ , while optical power at said wavelength  $\lambda_s$  remains substantially unattenuated thereby, each pump light-attenuating fiber section having first and second ends, the first end of each of said pump light-attenuating fiber sections being spliced to a respective one of the second ends of said gain fiber sections,

a filtering fiber, the ends of which are respectively connected to the second ends of said pump light attenuating fiber sections, said filtering fiber being doped with gain ions,

means for introducing pump light of wavelength  $\lambda_p$  into the first end of each of said gain fiber sections, and

means for introducing a signal of wavelength  $\lambda_s$  into the first end of one of said gain fiber sections, the gain ions of said filtering fiber remaining unexcited during operation

because of the pump light filtering action of said pump  
light-attenuating fiber.

37. A fiber amplifier comprising  
a gain optical fiber having only one single-mode core,  
said core containing dopant ions capable of producing stimulated  
emission of light within a predetermined band of wavelengths  
including a wavelength  $\lambda_s$  when pumped with light of wavelength  
 $\lambda_p$ , said gain fiber having input and output ends,

filtering means for attenuating light at at least some  
of the wavelengths within said predetermined band of wavelengths,  
said filtering means containing ions that can be excited by light  
of wavelength  $\lambda_p$ ,

means for introducing a signal of wavelength  $\lambda_s$  into  
said gain fiber input end,

means introducing pump light of wavelength  $\lambda_p$  into  
said gain fiber, and

means for preventing the excitation of said filtering  
means by light of wavelength  $\lambda_p$ .

38. A fiber amplifier in accordance with claim 37  
wherein said gain fiber is co-doped with signal light absorbing  
ions that are different from said gain ions.

39. A fiber amplifier comprising

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a gain optical fiber having only one single-mode core,  
said core containing dopant ions capable of producing stimulated  
emission of light within a predetermined band of wavelengths  
including a wavelength  $\lambda_s$  when pumped with light of wavelength  
 $\lambda_p$ , said gain fiber having input and output ends, said dopant  
ions being selected from the group consisting of erbium,  
neodymium and praseodymium,

filtering means for attenuating light at at least some  
of the wavelengths within said predetermined band of wavelengths,  
said filtering means containing a dopant selected from the group  
consisting of erbium, dysprosium, neodymium, ytterbium, samarium,  
praseodymium, thulium, vanadium and cadmium selenide,

means for introducing a signal of wavelength  $\lambda_s$  into  
said gain fiber input end, and

means introducing pump light of wavelength  $\lambda_p$  into said  
gain fiber.

40. A gain amplifier in accordance with claim 39  
wherein said filtering means comprises an optical fiber  
containing said dopant ions.

41. A fiber amplifier having a flattened gain spectrum  
comprising

a gain optical fiber having only one single-mode core,  
said core containing dopant ions capable of producing a gain

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spectrum due to stimulated emission of light within a predetermined band of wavelengths including a wavelength  $\lambda_s$  when pumped with light of wavelength  $\lambda_p$ , said gain fiber having input and output ends, and wherein the gain spectrum of said gain optical fiber over said band of wavelengths has a first portion having a relatively small gain variation over a region of said band wavelengths and a second portion having a relatively large gain variation over a different region of said band wavelengths, wherein said first portion of the gain spectrum is relatively flat and wherein said second portion is not flat and exhibits a greater gain than the gain exhibited over said relatively flat portion;

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ion filtering means for absorbing light within said predetermined band of wavelengths, said ion filtering means having an absorption spectrum having a first portion exhibiting relatively small absorption over said region of said band of wavelengths and a second portion having a relatively large absorption of said different region of said band of wavelengths where the gain spectrum is not flat, said ion filtering means comprising a concentration and distribution of unpumped gain ions within said ion filtering means wherein amplified light having wavelengths within said predetermined band of wavelengths where the gain spectrum is not flat is attenuated to an extent such that the gain spectrum over the entire predetermined band of wavelengths is flattened and exhibits relatively small gain

variation over said entire band of wavelengths;

means for introducing a signal of wavelength  $\lambda_s$  into  
said gain fiber input end,

means introducing pump light of wavelength  $\lambda_p$  into said  
gain fiber, and

means for preventing the excitation of said pumped gain  
ions by light of wavelength  $\lambda_p$ .

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42. A fiber amplifier comprising  
a gain optical fiber having only one single-mode core,  
said core containing dopant ions capable of producing stimulated  
emission of light within a predetermined band of wavelengths  
including a wavelength  $\lambda_s$  when pumped with light of wavelength  
 $\lambda_p$ , said gain fiber having input and output ends, and wherein the  
gain spectrum of said gain optical fiber, over said band of  
wavelengths and when pumped with light from wavelength  $\lambda_p$  has a  
first portion which is relatively flat and a second portion which  
is not flat and exhibits gain greater than the gain exhibited  
over said relatively flat portion;

filtering means for attenuating light at at least some  
of the wavelengths within said predetermined band of wavelengths,  
said filtering means containing ions that can be excited by  
light of wavelength  $\lambda_p$ , said filtering means having a  
transmission curve over said predetermined band of wavelengths

and in the absence of excitation by said gain fiber over said predetermined band of wavelengths when said gain fiber is excited by light at wavelength  $\lambda_p$  so that when light in the range of said predetermined range of wavelengths is amplified and filtered by said filtering means, the resulting gain spectrum for said amplifier over said predetermined range of wavelengths is substantially flat;

means for introducing a signal of wavelength  $\lambda_s$  into said gain fiber input end,

means introducing pump light of wavelength  $\lambda_p$  into said gain fiber, and

means for preventing the excitation of said filtering means by light of wavelength  $\lambda_p$ .

43. A fiber amplifier comprising  
a gain optical fiber having only one single-mode core,  
said core containing dopant ions capable of producing stimulated emission of light within a predetermined band of wavelengths including a wavelength  $\lambda_s$  when pumped with light of wavelength  $\lambda_p$ , said gain fiber having input and output ends, said dopant ions being selected from the group consisting of erbium, neodymium and praseodymium, and wherein the gain spectrum of said gain optical fiber, over said band of wavelengths and when pumped with light from wavelength  $\lambda_p$  has a first portion which is relatively flat and a second portion which is not flat and

exhibits gain greater than the gain exhibited over said relatively flat portion;

filtering means for attenuating light at at least some of the wavelengths within said predetermined band of wavelengths, said filtering means containing a dopant selected from the group consisting of erbium, dysprosium, neodymium, ytterbium, samarium, praseodymium, thulium, vanadium and cadmium selenide, said filtering means having a transmission curve over said predetermined band of wavelengths and in the absence of excitation by said gain fiber over said predetermined band of wavelengths when said gain fiber is excited by light at wavelength  $\lambda_p$  so that when light in the range of said predetermined range of wavelengths is amplified and filtered by said filtering means, the resulting gain spectrum for said amplifier over said predetermined range of wavelengths is substantially flat;

means for introducing a signal of wavelength  $\lambda_s$  into said gain fiber input end, and

means introducing pump light of wavelength  $\lambda_p$  into said gain fiber.

44. An optical fiber amplifier having a flattened gain spectrum for use over a wavelength range of about 1530 to about 1560nm comprising:

a gain optical fiber having only one core, said core

containing ions capable of producing stimulated emission of light within the band of wavelengths extending from about 1530 to about 1560nm when pumped with light having a wavelength capable of causing said stimulated emission in said band of wavelengths, said stimulated emission from said gain fiber exhibiting a gain spectrum including a peak around 1532nm and a substantially flat gain region extending from about 15460nm to about 1560nm, said gain fiber having input and output ends;

a gain spectrum fiber exhibiting an absorption spectrum and having an input end and an output end, one of the input and output ends of said filtering fiber being optically connected to one of the output and input ends, respectively, of said gain fiber, said filtering fiber having a core doped with ions which are capable of absorbing light according to said absorption spectrum within the band of wavelengths extending from about 1530 to about 1560nm, the absorption spectrum of said filtering fiber having a substantially non-flat absorption spectrum in the spectral region from about 1530 to about 1540nm and particularly at about 1532nm and having a relatively flat absorption spectrum in the region from about 1540 to about 1560nm, the absorption spectrum exhibiting a lower absorption in the region from about 1540 to about 1560nm than the absorption in the spectral region from about 1530 to about 1540nm and particularly at about 1532nm, one of the input and output ends of said filtering fiber being adapted for connection to a transmission fiber input end;

means for introducing pump light into at least one of the input and output ends of said gain fiber; and

means for introducing a light signal having a wavelength in the range from about 1530 to about 1560nm into the input end of said gain fiber wherein said pump light stimulated emission in said gain fiber over the wavelength range from about 1530 to about 1560nm and an amplified signal in the range from about 1530 to about 1540nm is not attenuated below a level about equal to the magnitude of an amplified signal in the wavelength range from about 1540 to about 1560nm.

45. The amplifier of claim 44 wherein said means for introducing pump light comprises at least two pump sources.

46. The amplifier of claim 44 wherein said amplifier is reverse pumped.

47. The amplifier of claim 44 which further comprises means between said gain fiber and said filtering fiber for filtering light in the pump wavelength spectrum.

48. The amplifier of claim 44 wherein the pump light has a wavelength centered around at least one of about 980nm and 1480nm.